



Environmental Influences on DESERT OPERATIONS

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Arid regions make up about one-third of the earth's land surface, a higher percentage than that of any other type of climate. Some of these regions—because of diverse and conflicting cultures, strategic importance, and natural resources—have become centers of conflict, as we have seen in the recent past.

U.S. Army leaders recognized early the potential for U.S. involvement in conflicts in these regions. About a decade ago, such exercises as BRIGHT STAR, which involved deployments by the 101st Airborne Division (Air Assault), paved the way for a renewed appreciation for combat in an arid setting.

At about the same time, the National Training Center at Fort Irwin, California, provided an opportunity for all U.S.-based forces to conduct exercises under desert conditions. After ten years, this training has paid off. The success of Operation DESERT STORM can be directly attributed to this realistic training experience.

All professional soldiers must continue to evaluate the restraints imposed by climate and terrain, particularly concerning desert operations. An appreciation of the effect of

arid conditions on soldiers (both physically and psychologically), on equipment and facilities, on combat operations, and on support will lead to success.

Climatic and Meteorological Conditions

Arid regions occur in response to specific climatic controls—latitude, land barriers, ocean currents, and land-water contrasts—which influence both moisture and temperature.

In arid regions, temperatures range from around 140 to -50 degrees Fahrenheit. The incoming solar radiation is intense. The absence of clouds allows higher energy absorption levels at the surface. As the sun's energy is absorbed, the surface heats up. The absence of vegetation increases the solar effect. The glare of the sun's rays is also intense because of the stability of the atmosphere. With nightfall, the absorbed energy is quickly released back into the air, causing relatively significant drops in temperature.

The actual principle that defines a desert is the low level of relative humidity, which is dependent on high temperature

or low moisture. Deserts have an annual average rainfall of ten inches or less, and evaporation exceeds precipitation. Rainfall results from convectional thunderstorm or frontal activity, and may be either seasonal or evenly distributed throughout the year.

It is important to realize that it does rain in deserts, as it did during the ground campaign of DESERT STORM, and it can be violent and cause flash floods. Runoff is exaggerated because of steep slopes and sparse vegetation.

Early morning fog can also exist in arid regions, especially along the coasts. As information from DESERT STORM indicates, the fog can be even thicker than that in Germany, and it caused movement concerns in some areas during the ground campaign. Although this type of condensation can provide water for consumption, it can also adversely affect equipment.

Infrequent but intense thunderstorm activity and frequent windstorms are the major disturbances associated with climate in arid regions. These events are dangerous for both soldiers and equipment and can totally disrupt military operations. During DESERT STORM, however, units were able to overcome the effects of these disturbances.

Terrain Analysis

Arid regions have three characteristic types of topography—basin and range, mesa and scarp, and flat sandy desert.

- Basin and range landscapes include mountains formed by folding and faulting or volcanos, and flat basin floors consisting of dry lake beds and salt flats.

- Mesa and scarp terrain is characterized by severe changes in slope, alternating between steep cliffs and more gently sloped debris cones. This topography ranges from plateaus to canyons, mesas and buttes, and finally to flat desert floors.

- Flat sandy deserts have a variety of sand dunes that are shifted across the desert floor by wind action.

The primary erosive agent in a desert is running water. Even though rain is infrequent, the water easily cuts the relatively soft surface material and, because of the lack of vegetation, creates deep channels. These channels, called *wadis* or *arroyos*, are dry until it rains and then can be filled with water.

Wind action is an obvious erosive agent, but its actual destructive work is less significant than that of water. Weathering also deteriorates rock material, causing dangerous rockfalls and landslides and resulting in talus slopes. Because of the ongoing erosion and lack of vegetation, slopes are generally much steeper in arid regions than in more humid areas.

The rock types in arid regions create a solid bedrock and serve as parent material for both coarse-grain thin soils and huge sand deposits. Finer clays may be found in dried lake beds. The fine texture material found in the DESERT STORM areas of operation created a dust that was particularly annoying.

The vegetation is generally sparse in arid regions and its

type, stem thickness, spacing, canopy, and height are important variations. Some deserts have widely spaced shrubs and cacti, while others have no plant growth except at oases and along wadis, where short, thin broadleaf deciduous shrubs grow about three feet tall.

During World War II, the 60th Infantry Regiment, 9th Infantry Division, described desert shrub in the Bizerte area of Tunisia as amazingly thick. Soldiers actually had to crawl to penetrate the shrub thickets. Other areas may have grasses and small bushes growing in patches, especially during the wetter season. Soldiers in DESERT STORM witnessed such "greening," which provides grazing for camels and sheep. But vast parts of the area of operation had absolutely no vegetation.

The wadis are the drainage features. They can be ten or more feet deep and tens of feet wide. With basin and range topography, channels flow to the basin and into the lakes, which are dry most of the year. Some wadis in Iraq and Saudi Arabia are so shallow that it is hard to tell where they are.

With such inhospitable conditions, few man-made features are found in the deserts. People concentrate in a major center, while small villages may exist near water sources. Roads are few, and great distances separate any settlements.

Military Aspects of the Terrain

Observation and fields of fire are excellent in most desert areas, since one can often see for tens of miles. The atmosphere is stable and dry, allowing unrestricted views over vast distances, but this can also be a problem. Range estimation by "gut feeling" is subject to error. The effective ranges of weapons can be easily reached, and a correct estimation of maximum range is critical for all weapons, especially for wire guided antitank missiles.

Things look closer than they really are. Problems may also result because observation is distorted by surface heat waves that create mirages. The wave distortion is especially accentuated when using optics for observation, range determination, or weapon siting. Heat haze can distort a target so that, depending on its size, it cannot be identified, or even seen, as close as 200 meters. Sensors are also affected by heat shimmer.

Frequently, in desert regions, especially in the DESERT STORM area of operation, there are no landmarks to use. This presents problems for land navigation. A compass and a vehicle odometer must be used to get to the desired location. Another concern is dead space. Even though the landscape appears flat, upon closer inspection it can be undulating with relatively deep wadis and depressions, and these areas must be covered by indirect fire. Additionally, sand dunes and hilly terrain limit observation and fields of fire, and the frequent dust storms can reduce visibility for periods of as little as a few hours, or for several days.

Key terrain in the desert can be almost any man-made feature, a mountain pass, or a source of water, and, of course, high ground. Because there are few man-made features

throughout the expanse of the desert, those that do exist can become important, perhaps even key.

Settlements (where a logistics base may be established), road junctions, shelters, airfields, all become important, simply because they are so few in number. In areas involved with DESERT STORM, paved and even dirt roads were considered key terrain for both high-speed movement and clearly defined direction and location.

Passes through steep topography are also likely to be key, again because they are so few. The North African campaigns of World War II focused on the control of passes, specifically the Sollum and Halfaya. In the Sinai Wars between Egypt and Israel, the Mitla, Giddi, and Sudar passes were key. In Afghanistan, control of the mountain passes provided the Mujahideen safe haven from the Soviets. The oases, where wells exist, become important for water resupply. Units in DESERT STORM found these wells a great source of water. The high ground is always a sure bet for key terrain. The relative flatness and great distances of some deserts, such as in Iraq, make even a large sand dune a dominant feature.

Natural obstacles do exist in the desert, and arid regions are well suited for man-made obstacles. The wadis and steep slopes of escarpments, mountains, hills, and dunes hinder cross country movement. Sand dunes may stretch for miles and prevent direct movement across their length. These sand dunes are often more than 100 feet in elevation and consist of loose sand with high, steep downwind faces that make vehicular traversing next to impossible. In the DESERT STORM area, the salt marshes have crusts on the top that can deceive a vehicle driver. These dry lake beds can become obstacles, especially in the wetter season when the water table is higher. A top crust forms on the surface, but below this crust the soil is moist, similar to marsh conditions. The surface looks like it will have good trafficability, but the crust collapses with the weight of a vehicle and it becomes mired. The high premium on fuel and time makes it costly to go around these natural obstacles. Aerial reconnaissance, immediately before any large movement, is highly advisable, because sand dunes migrate with shifting winds and they may not be where the maps or even photos show them.

Sandy deserts are ideal for employing minefields. Although windstorms can reveal previously buried mines, these mines can still channel movement and deny access to certain areas. The battles of the Bi'R Hacheim Line and El Alamein were influenced by minefields. Other obstacles include ditches, revetments, and barriers, such as the Bar-Lev Line along the Suez Canal, made by bulldozing sand into mounds or by blasting in rocky, mountainous areas to close passes. The Iraqi engineers were superb in their obstacle emplacement. Fire trenches, wire, and minefields stretched across the entire border.

Cover and concealment can be limited in desert regions. The flat sandy deserts provide little, if any, natural cover or concealment, especially from aerial attack or reconnaissance. Ground concealment and protection from fire can be found behind the dunes or in the wadis. When using wadis for

ground concealment, soldiers must be aware of the potential for flash floods.

Some arid regions have vegetation that can provide limited concealment from ground observation. In rocky, mountainous deserts, cover and concealment are best behind large boulders and in crevasses. Daytime vehicular movement eliminates nearly any possibility of concealment or surprise, as dust trails created by the traffic can be spotted for miles. At night, noise and light discipline is critical, as both sounds (from generators and other equipment) and light travel great distances because of the unobstructed flatness and the atmospheric stability. Camouflage can be very effectively employed to improve on natural concealment. Experience in DESERT STORM indicated that desert camouflage nets work well in the more rugged terrain, because they blend in nicely with the color of the soil and rock.

Avenues of approach are not clearly defined in arid regions. The vast, relatively flat areas permit maneuver from virtually any direction. This point became obvious to units establishing defensive positions in DESERT SHIELD. Wide envelopments are possible, as demonstrated in the DESERT STORM ground campaign. Modern sensor technology, limited natural concealment, and improved observation make the element of surprise a challenge. Yet, surprise was achieved in DESERT STORM. Iraqi commanders were shocked when they discovered U.S. tanks in their perimeters.

The major limitation with respect to avenues of approach may be fuel. The great distances a unit must travel to outflank enemy positions require huge amounts of fuel and complicate resupply. This was a concern during DESERT STORM, but logistics and transportation units successfully met the challenge. In mountainous and canyon topography, avenues of approach are much more limited, and the wadis and valleys are likely to be the only possible access routes. Any roads that do exist are probably in the valleys. Nevertheless, none of the considerations outlined above are reasons to preclude the use of such tactics.

Effect on Soldiers

Conditions in arid regions are hazardous to the safety of soldiers and also affect their performance, both physically and psychologically. High temperatures, dryness, and wind can wear them down if they are not properly acclimated and trained to respond to these physical conditions.

Although it is not always feasible, the soldiers may need to live in arid conditions for two to four weeks before they are ready to endure the rigors of the desert. If they know the way desert conditions affect the human body, they can take precautions, and they gain this knowledge through training. Part of training is learning to conserve energy and working wisely—for instance, at night during cooler periods. During the initial deployment period of DESERT SHIELD, units started their day in the early morning, took a break from 1100 until 1500, and then worked until sunset or sometimes well into the night.

**Helicopters of 82d Aviation
Brigade in Saudi Arabia
during Operation DESERT
SHIELD.**



The intensity of solar radiation can cause severe sunburn, and the glare can injure eyes. The precautions are simple. The soldiers should wear sunglasses, and their clothing should be lightweight and loose fitting, and should cover as much of the body as possible. Wearing clothes properly and developing a suntan gradually (five minutes a day) will prevent burning. Soldiers can also be burned when they touch hot metal; tools and vehicles left in the sun can reach 170 degrees Fahrenheit.

Soldiers learned in Saudi Arabia just how cold desert temperatures can be at night. Temperatures drop significantly as the absorbed solar radiation is re-radiated into the atmosphere. The body needs to be completely covered to maintain warmth. The extreme daily temperature changes can subject soldiers to colds and other respiratory conditions.

Evaporation occurs continuously because of the high temperature and the dry atmosphere. Water is evaporated through sweating and must constantly be replaced. A soldier may lose six quarts of liquid per day doing light work or 13 quarts doing heavy work. A two-quart loss of body fluid can decrease performance by 25 percent while a 12-quart loss can be fatal. To prevent heat-related injuries, soldiers should drink about two gallons of water daily in small amounts, especially in the hot summer.

Being fully clothed helps a soldier retain the cooling moisture on his skin. This is another reason to make sure the uniform is worn correctly. Commanders in DESERT SHIELD and DESERT STORM concur with this point. The hot dry air causes high perspiration rates; skin may appear dry and allow evaporation to go unnoticed. Urine should be checked and if it is particularly dark, it is an indication of dehydration.

Soldiers who do not monitor their water intake may be subject to injuries from excessive loss of body fluid. These injuries include heat exhaustion (which causes dizziness and confusion), salt deficiency (resulting in fatigue, nausea, and cramps), and heat stroke (in which the body's cooling system breaks down and can lead to death). Alcohol and smoking can compound the effects of dehydration.

Because of the constant wind, blowing sand, and dust, protective goggles and ointments may be required to protect the eyes, especially for soldiers riding in open vehicles. Bandannas should be worn to cover the mouth and nose. In DESERT SHIELD and DESERT STORM, soldiers experienced the effect of being constantly sand-blasted.

Because of water shortages, sanitation and personal hygiene are often difficult in arid regions. But if sanitation and hygiene are neglected, disease may cripple units. Diseases transmitted by flies and mosquitoes should also be a major concern of all soldiers. Dengue fever, dysentery, cholera, typhoid, diarrhea, fungus infection, and prickly heat plague soldiers in arid regions. When a soldier gets diarrhea, for example, his body dries out quickly and medics must administer intravenous fluids. To reduce the effects of illness in DESERT SHIELD and DESERT STORM, the chain of command placed great emphasis on sanitation and hygiene.

The "critters" of the desert are another potential risk. It is wise to be alert for scorpions, centipedes, spiders, and snakes in the comfort of cool places, because they seek shade just as humans do. Comments from commanders in DESERT SHIELD-STORM indicated these "critters" were around but had not been nearly the problem they expected.

Twisted ankles or cuts from jagged rocks can result in minor injuries that can incapacitate a soldier and also require another soldier to care for his injury and carry his load. Rockfalls are dangerous, and soldiers should be on alert for cliff instability in mountains and canyons. Even the vegetation can cause injury. Cactus needles and shrub thorns can tear clothing and skin, and the danger of infection is real.

From the psychological perspective, the monotony of the desert, its emptiness, and the fear of isolation or possible physical harm can all affect soldiers eventually. DESERT SHIELD and DESERT STORM commanders indicated that the first weeks of the deployment were especially tough in this regard. Nearly everyone simply hated the Saudi desert.

The relatively constant climatic conditions add to this monotony, and boredom lowers morale. These effects must

be attacked; if a soldier's psychological condition becomes weak, physical dangers can overcome him. To reduce boredom during DESERT SHIELD, commanders made good use of the training opportunity to prepare for hostilities, and the intensive training also kept morale high.

Effect on Equipment and Facilities

Conditions in an arid environment can damage military equipment and facilities. Temperature and dryness are major causes of equipment failure, and wind action lifts and spreads sand and dust, clogging and jamming anything that has moving parts. Vehicles, aircraft, sensors, and weapons are all affected. Rubber components such as gaskets and seals become brittle, and oil leaks are more frequent.

As commanders in DESERT SHIELD and DESERT STORM have often said, the desert takes a particularly heavy toll on tires. Tires absorb the surface heat, their structure is weakened, and jagged rocks or even cactus vegetation can cause punctures. Tire pressure must be constantly checked and adjusted. The large temperature variations between day and night change the density of the air in them; they will deflate at night and inflate during the day. The same is true of any inflatable containers. If they are full at night, expansion during the day can burst them. The same phenomenon applies to liquids. Fuel tanks or water containers that are filled to capacity at night can overflow during the heat of the day.

Vehicle engines are subject to greater strain because of heat. With each ten-degree rise in temperature above 60 degrees Fahrenheit, a one percent loss in vehicle power can be expected. In the heat of the day, that means a loss of six to seven percent. Frequently, lower gears must be used to negotiate the loose sandy soil, and this also strains engines and transmission systems.

Cooling systems must be constantly checked to reduce overheating. Glass is also affected by intense radiation. It can actually crack or glaze over. And batteries are not likely

to hold their charge, especially if too much of the electrolyte evaporates.

Today's Army relies heavily on the electronics in computers, radios, sensors, and weapon systems. The intense heat only adds to the inherent heat that electrical equipment generates. Even in temperate regions, air conditioning is often required for much of our equipment to function properly. Radio operators in DESERT SHIELD and DESERT STORM found that their radios heated up faster; they covered the equipment with damp rags or provided some sort of shade to cool it. Obviously, in the desert environment, air conditioning is needed but it adds another fuel burden.

Heat must also be considered with respect to weapon effectiveness, not just from the components' operation but also in target acquisition and engagement. Sensors and scopes only magnify the heat shimmer or mirage. Targets become distorted, precise locations can't be determined, and gunners miss their targets. Automatic weapons and rapid-firing tank and artillery guns overheat faster, increasing barrel wear and the potential for malfunctions. Rounds may cook off more frequently. The dryness of the soil makes grounding electronic equipment a challenge. In DESERT SHIELD and DESERT STORM, it was difficult to hammer a grounding rod into the soil, and to get a good ground, water and salt had to be poured onto the grounding rod constantly.

The winds blow sand into engines, fuel, moving parts of weapons, electronics, and everything else, and this can reduce equipment life by up to 80 percent. Soldiers must continuously clean and check their equipment. Within jet engines, the sand particles can actually melt into glass, dead-lining the equipment. The rotors of helicopters, turbines, and engine fans are sand blasted, again causing major maintenance and supply demands. This sandblasting also affects optical glass and windshields and distorts the view through them. Protective paints and camouflage become worn quickly. Shelters, tents, and ropes are also subject to increased wear.

In addition to these effects, such natural hazards as flash



Soldiers and HMMWVs in the desert sand heading toward the tent city during Operation DESERT SHIELD.

floods, thunder and lightning storms, landslides and rock-falls, and windstorms can destroy equipment and facilities. (The windstorm that damaged more than 100 helicopters at Fort Hood in 1989 is an example of this potential force.) Storage sites and cantonment areas should be located on the higher ground away from a wadi, but should not silhouette equipment on the horizon. During the rainy season, lightning rods need to be in place. In canyon-like topography, the stability of cliffs needs to be evaluated. Rockfalls and landslides are especially dangerous for equipment and facilities that may be located at the base of slopes.

Effect on Combat Operations

The key to success in desert operations is mobility, and this was clearly evident in ground operations of DESERT STORM. The tactics employed to achieve victory over Iraq were the wide, rapid flanking movements Rommel and Montgomery demonstrated in North Africa.

Trafficability and cross country movement then become critical to the tactics of desert operations. Trafficability is generally a "go" in the desert and cross country movement a lesser problem, but not always. As previously mentioned, salt marshes can create "no go" conditions during the wetter season. Sand can also bog down traffic and make foot movement slow and exhausting. The steep slopes of dunes and rocky mountains can make vehicular movement a "no go." The wadis can create cross-compartmented terrain. The banks of these dry streams can be steep and unconsolidated. Then when it rains, the wadi becomes a torrent of dangerously rushing water, leading to flat lake beds that can create "no-go" mud conditions. In rocky areas, tires can easily be punctured by sharp angular debris. But, overall, movement is mostly uninhibited. And given ample fuel and water resources, units can go around natural and man-made obstacles.

With the loose surface material, movement can easily be detected because of the sand and dust it kicks up. In an actual engagement, this may not be all that bad because a unit is obscured from direct fire while advancing, but the element of surprise is probably lost. Moving at night becomes the logical choice. The dust is still there, and vehicles (which should be widely spaced) can get separated. But at night, there is no worry about the reflection of the sun's rays from glass, mirrors, or metal, which can give away movement and positions at distances up to 20 kilometers.

Using the ability to make fast wide flanking movements, a unit can encircle and cut off enemy forces. The Israeli forces under General Ariel Sharon did just that to the Egyptian Third Army in the 1973 War, and the British did the same to the Italians in North Africa in January 1941. In DESERT STORM, the night-fighting AH-64 helicopters combined with field artillery fires made for an unbeatable team in this regard. An armored force raced to the Euphrates River and to static Republican Guard positions, cutting off and destroying Iraqi divisions.

During movement in the wide expanses of many arid regions, land navigation is a challenge. There are few landmarks to key on, and maps and even photos can become outdated quickly, especially in the sandy deserts where dunes migrate. The Global Positioning System (GPS), with the Small Lightweight GPS Receivers (SLGRs), is a major aid for desert operations. Commanders in DESERT SHIELD and DESERT STORM were especially pleased with this equipment. The use of imagery gave the commander up-to-date and timely intelligence and mapping products.

Refuel and resupply operations require periods in which forces assume the defense, but only temporarily. The flat sandy desert topography that is characteristic of Saudi Arabia is not conducive to defense, compared to basin and range or mesa and scarp topography. In mountains and canyons, a defensive posture can be more favorable. Controlling the passes, as mentioned earlier, can essentially close off vast areas to an attacker and make it extremely costly for him.

While a unit is in the defense, it needs both ground and air reconnaissance to detect movements at long range and as early as possible. Obstacles must be emplaced in all types of topography, primarily to slow advances and channel columns. Neglecting these security measures in the flat sandy regions can lead to disaster.

Commanders in DESERT STORM indicate that the enemy was engaged early and at the maximum ranges of weapon systems. They felt that observed fires had to be used because the enemy could move so quickly. OH-58 helicopters, used with AH-64s and long range artillery systems, were the means to this end. But the Iraqis did not really move that much, and unobserved fires, using imagery intelligence, resulted in major kills.

Logistical support becomes more critical in arid regions because of the few man-made features and the lack of resources available from the terrain. Although the influence of logistics weighs heavily on operations, it cannot be allowed to dictate the plan. The plan, whether in the offense or the defense, must consider fuel and water much more seriously, and the logistician must specify the support requirements and plan to meet them. The commander must give the logistician what is needed to keep operations from bogging down.

Combat units may become isolated, which creates intolerable situations for these units and the rest of the theater. The DESERT STORM experience demonstrated the success of logistical planning and execution, and the balance of operations and logistical support.

Effect on Combat Service Support

Support is always a challenge, and an arid environment burdens all types—supply, aviation, communications, and maintenance. Commanders must be sensitive to the constraints, and those providing support must work to overcome them.

Support in desert regions is dependent on a base. A base should be a major transportation-communications hub with a deep water port, major runways, pipelines, road and rail access, storage areas and facilities, and a source for fresh water. The dispersal of the base components is critical, however, and air defense assets must be allocated to reduce the air attack threat.

Such is the ideal, and the ideal is available for most desert regions, but there may be only one such support base, and lines of communication (LOCs) may be 1,500 miles long, as they were in the North African campaigns of World War II. Dhahran, Saudi Arabia, served as the logistics base for DESERT SHIELD and DESERT STORM, and it met the criteria.

Long LOCs require convoys from the support base to the combat forces, and convoys are subject to air attacks (as learned during World War II when convoys from Casablanca to Al Guettar, Tunisia, were frequently targeted by Luftwaffe raids). Night movements appear to be the solution. The Global Positioning System will reduce the major problem, which has always been land navigation. Road networks are limited in arid regions and often channel convoys, and engineers must be devoted to road construction and maintenance. Experience in DESERT SHIELD and DESERT STORM confirms that heavy traffic and prevailing winds raise havoc with roads. The two-lane Tapline Road (MSR Dodge) running from north of Dhahran all along the border between Saudi Arabia and Iraq was the life line of DESERT SHIELD and DESERT STORM and carried a continuous flow of trucks, day and night.

The supply base obviously becomes an enemy objective. Commanders who plan wide envelopments must always have both ground and air forces available to protect the base and the road network. (Dhahran was a major Iraqi Scud target.)

The support element must have facilities for storage and issue, and the few existing facilities may need augmentation. Warehouses, refrigeration units, fuel and water bladders, and maintenance facilities will have to be constructed. Transportation nodes, road, rail, pipeline, port, and air facilities will have to be upgraded.

Aviation support is critical because of the limited road resupply, but both helicopters and fixed winged aircraft are handicapped in arid regions. In addition to excessive wear on parts from wind and sand action, an additional concern is reduced performance, especially with increased temperatures. The hot air is less dense, and this reduces aircraft lift capabilities. The reduction in lift capability hampers the movement of artillery, the delivery of supplies, and the evacuation of units in trouble. Again, night and early morning are the ideal times to conduct airlift operations. Commanders in DESERT SHIELD and DESERT STORM had experienced the lift problems and had made adjustments.

Communications support is also adversely affected by high temperature. The heat causes anomalies in radio and other electrical transmissions, and radio battery life is reduced in the hot temperatures. Radio range is shorter during the day than at night. FM communications range can be reduced by as much as 50 percent because of high temperatures. HF ground wave propagation over the dry sandy soil is reduced. At night, range improves but static electricity may cause interference.

Night communications, with longer ranges, make communication security a concern, as it always should be. Experience in DESERT SHIELD and DESERT STORM indicates vastly expanded ranges with FM radios. Communication between units 40 to 50 kilometers apart was not unusual. Communications obviously affect command and control as well as intelligence collection and dissemination, and their importance must not be underestimated.

Maintenance is a critical sustaining function for military operations. Repairs are dependent on the soldiers and the facilities. The arid conditions affect the soldiers' performance, and the likelihood of fewer hardstands, wash racks, and shelters adds to the challenge of maintenance operations. The biggest irritant is probably wind that blows sand and dust on component parts and into exposed valves. Creating shelters that are free from these effects is difficult, to say the least. In short, repairs take longer, and preventive maintenance at all echelons requires continued command emphasis.

DESERT SHIELD and DESERT STORM commanders have said that even simple operations such as changing wheel bearings were difficult. Maintaining helicopter operational readiness rates required significant innovative techniques, and tentage was a must for nearly all maintenance operations. Yet throughout the war, combat aircraft maintained an amazing 94 percent combat ready rate.

As in all climatic regions, an arid region imposes both opportunities and restraints on soldiers at all levels. The Army has once again successfully fought battles in an arid region; these opportunities and restraints are no longer new. The effects on soldiers, equipment and facilities, operations, and support were understood and addressed. In conducting operations in the future, professional soldiers need only to review these effects and again emphasize them to reduce casualties and to use the environment to advantage.

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